Scanning Tunneling Microscopy of Superconductors

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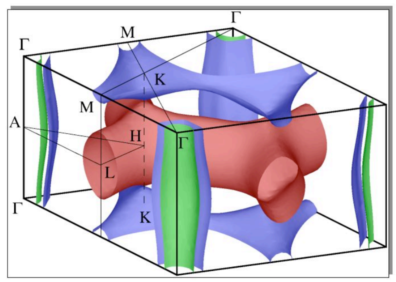
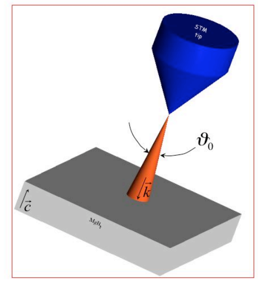
Motivation

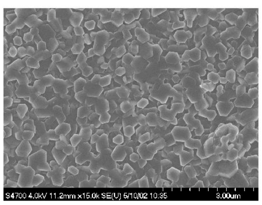
Scanning tunneling microscopy is an effective tool to study superconductivity on an atomic scale. Topographic and spectroscopic STM studies of superconductors provide a wealth of information to help us understand the microscopic mechanism of superconductivity.
Recently discovered superconductor magnesium diboride, MgB_2, is the first example of two-band superconductor.
Band structure calculations for this highly anisotropyc material, suggest that superconductivity is due to the coupling of the two-dimensional bands of the Boron sheets. Superconductivity arises on the 3D bands due to interband electron-phonon coupling and pair coupling between the 2D and the 3D bands.
Combination of scanning electron microscopy (SEM) and scanning tunneling microscopy (STM) breaks new ground in our fundamental understanding of microscopic superconducting properties of MgB_2.

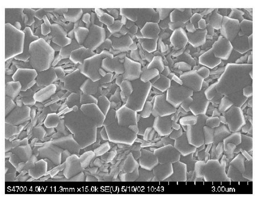


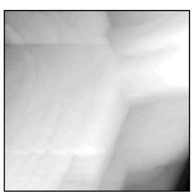


Results

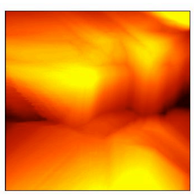
SEM and STM of MgB_2 Thin Films







300 nm x 300 nm



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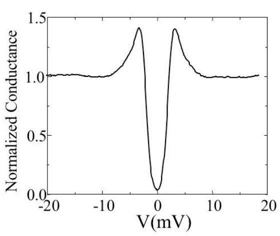
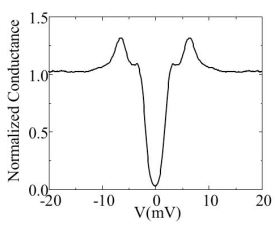
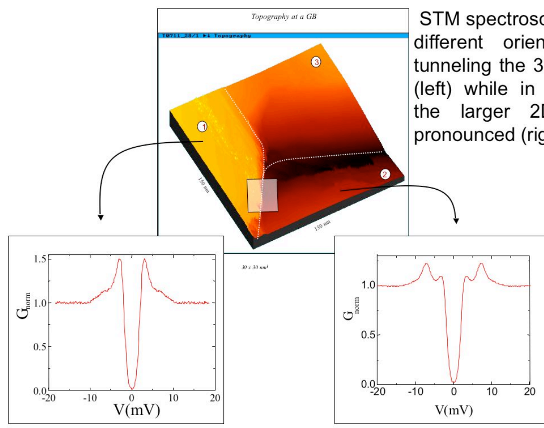


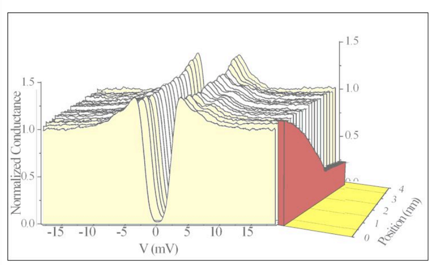


SEM micrograph of some MgB_2 thin films show hexagonally shaped crystals with c-axis randomly oriented with respect to the substrate. Some crystallites are oriented with the c-axis pointing in the plane of the figure while some have the c-axis perpendicular to the substrate. STM topography images, on a smaller scale, confirm these findings. The tunneling spectra obtained on the ab-plane oriented grain consistently show the two gaps associated with the different sheets of the Fermi surface.

STM topography and Spectroscopy in MgB_2 pellet



STM spectroscopy on grains with different orientation. In c-axis tunneling the 3D gap is dominant (left) while in a/b-axis tunneling the larger 2D gap is more pronounced (right).



Tunneling spectra recorded at different locations while scanning the STM tip across a step on a thin film surface.

Future Directions

Our future research will be focused on the understanding of superconductivity and vortex behavior in MgB_2 in the presence of magnetic and non-magnetic impurities.

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